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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Docket Number	040072-275	Type a plus sign (+) inside this box →	+

INVENTOR(S)/APPLICANT(S)

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TITLE OF THE INVENTION (500 characters max)

METHOD AND SYSTEM FOR ASYMMETRIC DUAL-MODE RADIO COMMUNICATIONS

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ENCLOSED APPLICATION PARTS *(check all that apply)*

[X] Specification *Number of Pages* 1 - 6 [X] Drawing(s) *Number of Sheets* 5

[ ] Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(CHECK ONE)*

[ ] Applicant claims small entity status. See 37 CFR § 1.27. [X] A check or money order is enclosed to cover the Provisional filing fees. [X] The Director is hereby authorized to charge any deficiency in filing fees or credit any overpayment to Deposit Account Number 02-4800. This paper is submitted in duplicate.	PROVISIONAL FILING FEE AMOUNT(S)	$ [ ] $80.00 (2005) $ [X] $160.00 (1005)

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[X] No.

[ ] Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE Kenneth B. Leffler Date October 17, 2003

TYPED or PRINTED NAME Kenneth B. Leffler Registration No. 36,075 *(if appropriate)*

[ ] Additional inventors are being named on separately numbered sheets attached hereto

SEND TO: Mail Stop Provisional Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

(10/03)

patent disclosure for

METHOD AND SYSTEM FOR ASYMMETRIC DUAL-MODE RADIO COMMUNICATIONS

1. FIELD OF THE INVENTION

The invention relates to the area of data communications. In particular, the invention relates to radio communications with different channels in uplink and in downlink.

2. BACKGROUND

In the last decades, progress in radio and VLSI technology has fostered widespread use of radio communications in consumer applications. Portable devices, such as mobile radios, can now be produced having acceptable cost, size and power consumption. Mobile phone communications for the consumer market started with phone systems derived from the police and rescue services and was based on an analog technology improved and optimized in the seventies and eighties. Examples of these analog phone systems are NMT and TACS. The usage of mobile phones really took off in the nineties with the introduction of mobile phone systems based on digital technology like GSM, D-AMPS and PDC. Generally, the analog systems are indicated as being the first generation, whereas the digital systems are indicated as second generation.

Momentarily, third generation systems are being worked on. Two different paths can be distinguished. One path considers complete new systems based on a technology that differs from the previous generation. For example, the third generation mobile phone system UMTS being developed in Europe (and also Asia and the US) although digital, is based on wideband transmission whereas most second generation systems are based on narrowband transmission. The other path considers high data rate modes in the existing second-generation systems. An example is the EDGE mode applied in GSM and in D-AMPS. In the latter case, a second-generation system is updated to a third generation system through the use of high rate modes.

This general trend of updating an existing system by adding dedicated functionality like higher data rates, is attractive since the system basic functions like control and mobility support can still be based on the conventional system operation whereas only dedicated modes make use of the advanced features. Compatibility with existing portable devices is guaranteed.

A limitation in the current solution is that, for example, to establish a dedicated high-speed link, both sender and recipient must be capable of supporting the higher data rates. Although trivial at first sight, this is not at all the case when it is understood that for many of the applications where high data rates are desired, the increase in data rate is desired in one direction only. As an example is mentioned a printer device. When a laptop wants to download a file on a printer, for example via a short range radio link like Bluetooth, the increased data rate is required only in the direction from the laptop to the printer. The return channel from the printer to the laptop is only required to support basic data link control (DLC) messages and other link related signaling. The return channel can easily be supported by the conventional radio link. It will be understood that an information sink like a printer preferably has an advanced receiver for high-rate reception. The transmitter, though, can be of a simple type as only low data rates have to be supported in the transmit direction seen from the printer. Alternatively, examples can be found of typical information sources. Consider a digital camera. The user wants to draw the pictures out of the camera at high speed; never will pictures be loaded into the camera. Therefore, the camera preferably has an advanced transmitter for supporting high data rates whereas the receiver can be fairly simple. Since the complexity of a high-rate radio transmitter is very different from the complexity of a high-rate radio receiver, it is recognized that the benefit of adding high-speed modes can be importantly improved by taking into account the asymmetric speed requirements.

It is the intention of this invention to provide a system where high-speed modes can be supported with reduced costs if asymmetry in the speed requirements is present.

3. SUMMARY

The invention describes the separation of transmitter and receiver functionality in dual-mode radio transceivers to support high-rate services. In order to support both the conventional (low-rate) and high-rate air interfaces, radio transceivers are usually designed to support both schemes. The current invention addresses systems with highly asymmetric requirements that need only a high-rate transmission or only high-rate reception functionality. The conventional air interface is used for conventional support functions like connection setup, link supervision and so on. In addition, a high-rate transmitter is included to support pushing data out of the terminal at high data rates for terminals with a typical source functionality like (digital) camera's or CD players. Alternatively, a high-rate receiver is included to support pulling data into the terminal at high data rates for terminals with a typical sink functionality like a printer or a display. In both cases, the feedback or return channel supporting the communications over the high-rate link is transferred over the low-rate air interface. This allows sink terminals to avoid implementing (advanced) high-rate transmitters, whereas it allows source terminals to avoid implementing (advanced) high-rate receivers. Applications with a strongly asymmetric behavior allow radios with asymmetric transceiver implementations. This puts a different view on dual-mode

transceivers as the dual-mode can refer only to the transmission or refer only to the reception.

In order to support the message exchange at the higher levels, the OSI model is split at the physical layer. As a result, the data link control and media access layer are carried on the high-speed physical channel in one direction, whereas they are carried by the conventional physical channel in the reverse direction.

With the invention as described, wireless devices will obtain the possibility to send information at high rate with little additional implementation cost. Return information is received with the conventional receiver.

4. LIST OF FIGURES

Figure 1. Conventional single-mode transceiver for symmetric usage.

Figure 2. Conventional dual-mode transceiver for symmetric usage.

Figure 3. Typical asymmetric applications with and a) a camera as information source, b) a printer as information sink.

Figure 4. Dual-mode, asymmetric connection.

Figure 5a. Dual-mode transceiver with advanced transmitter for asymmetric usage according to the current invention.

Figure 5b. Dual-mode transceiver with advanced receiver for asymmetric usage according to the current invention.

Figure 6. Conventional OSI model for low-rate and high-rate modes.

Figure 7. OSI model to support low-rate and high-rate modes according to the first embodiment in the current invention.

Figure 8. OSI model to support low-rate and high-rate modes according to the second embodiment in the current invention.

5. DETAILED DESCRIPTION OF INVENTION

Radio implementations have improved considerably compared with the equipment Marconi was using at the turn of the last century to send the first radio messages across the Atlantic. However, although size, power consumption, and price have reduced dramatically with the advent of silicon integrated circuitry, the basic radio transceiver architecture has not changed that much. A schematic diagram of a radio transceiver is shown in Figure 1. Information is provided by a host system (cellular phone, PDA or any other electronic equipment) over the I/O interface. In most

modern systems, this information already has a digital format. In the MAC/DLC controller, this information is prepared to be transferred over the wireless interface. For example additional control information is added in the form of error control bits. At the proper moment in time that may depend on the type of medium access control (MAC) scheme, the data is ready to be transmitted over the radio channel. The information is then packetized by the baseband controller, again error control information may be added; then, the digital bits are mapped onto symbols appropriate for RF transmission. This baseband signal is then provided to the radio TX part. There, the baseband signal is properly shaped and converted to a suitable RF frequency (e.g. in the range between 0.5-5 GHz), amplified by the power amplifier (PA) and transmitted by the antenna. In the return path, the RF signal is picked up by the antenna, amplified by the low-noise amplifier (LNA) and down-converted and filtered in the radio RX part. In the baseband, timing and frequency synchronization are applied and the symbols are retrieved and are mapped to bits. Error correction maybe applied, as well as equalization and other recovery techniques. The payload in the received packet is then provided to the MAC/DLC controller which applies further checks and operations according to the DLC protocol. Finally, the received information is provided to the I/O interface and offered to the host system.

Many systems today are applied with additional modes to optimized specific functionality like for instance the data rate. As an example, in the cellular phones based on GSM, additional EDGE modes can be included for packet-switched communications and higher data rates. Another example is Bluetooth, where higher rata modes are being developed. Since the basic radio in GSM or Bluetooth transceivers can only support the basic air interface, additional circuitry has to be added to support the high-rate modes. For example, in GSM, the basic GSM air interface uses a GMSK constant-envelope, non-linear modulation which allows class-C transmitters and limiting receivers. In contrast, EDGE uses a linear, 8-PSK modulation which requires more advanced radio transmitters and receivers. In a similar fashion, the basic Bluetooth air interface applies a 1-MHz wide, nonlinear constant-envelope, GFSK modulation allowing class-C transmitters and limiting receivers. The high-rate mode being developed uses a 4-MHz wide PSK modulation requiring more linear transmitters and receivers. Terminals that are dual mode, include both classic transceivers and high-rate transceivers, an example of which is shown in Figure 2. The classic air interface is supported by the baseband_1 TX / radio_1 TX on the transmit side and the baseband_1 RX / radio_1 RX on the receive side. The high rate mode is supported by the baseband_2 TX / radio_2 TX on the transmit side and the baseband_2 RX / radio_2 RX on the receive side. Depending on which mode is used, the PHY control chooses the circuitry 1 or 2.

In practice, many applications have an extremely asymmetric traffic behavior. Take as an example, take a digital camera in Figure 3a. The input to the camera are the pictures taken by the user. The user may then wish to transfer the pictures taken to another medium like a disk storage, a PC, or a color printer. This can be achieved via a wireless link between the camera and this other medium. However, it will be understood that the data stream will always be from the camera to the external medium

and never the other way around. Another example is shown in Figure 3b. Shown here is a printer. The user may transfer data wirelessly from their portable devices like laptop, PDA, cell phone, digital camera, to the printer to be printed. Never is traffic expected from the printer to the portable devices. So basically, the printer only needs a receiver. Yet another example not shown is a browser with a display to surf the Internet over the cellular network. The dominant traffic is from the network to the browser and not vice versa. These examples show that many application only require a transmitter or a receiver for their traffic. However, two-way connections are always necessary for supporting functionality. To name a few, at initial connection setup, both ends need to be able to exchange information regarding the channel, authentication, encryption, and other supervising functions. Also, in data communications, automatic retransmission protocols are often used to resend messages that were corrupted at reception. All these supporting function do not need extremely high data rates, but require a transmit/receive combination in any unit. However, once the connection is established, a high-rate link may be initiated into one direction to speed up the data flow; yet, return control information may be carried over the (low-rate) basic link, see Figure 4. In Figure 4, link 1 is a bi-directional link for the exchange of control information between units A and B. Link 2 is a uni-directional link to transfer user information from unit A to unit B. In this case, units A and B need both a transmitter and receiver for link 1; however, unit A only needs a transmitter for link 2 whereas unit B only needs a receiver for link 2. An example of a transceiver architecture for unit A is shown in Figure 5a. Here, the receiver chain for link 2 is absent. This means that the advanced receive circuitry for processing of high-rate signals is not present. For example, in the case of Bluetooth and its high rate mode, the receiver section only consists of a basic Bluetooth receiver which can be based on a limiting, non-coherent concept. To support the high-rate mode, only the transmitter needs to be modified to support the more advanced signaling scheme. Alternatively, in Figure 5b, the transceiver architecture for unit B is depicted. Here, only a transmitter for link 1 is present. Both the basic receiver 1 and the advanced receiver 2 are implemented in this information sink unit. For Bluetooth high rate, the receiver 2 may be linear, use equalization, and other advanced signal processing techniques. All in all, both the implementations of unit 1 and of unit 2 are reduced in cost as it only implements either the TX part or the RX part of the advanced air interface corresponding to its typical usage.

Communication protocols are usually constructed according to the OSI layered model. In this specification, only the lower layers of the OSI model are considered (i.e. the application and presentation layers are ignored). Figure 6 shows the protocol stack in units A and B assuming they have both implemented a conventional dual-mode radio with transceivers for bi-directional transfer on links 1 and 2. Each layer in one unit has its corresponding layer in the other unit. The dashed lines represent the different protocols supported on link 1 while the thick, solid lines represent the different protocols supported on link 2. Figure 7 shows the protocol stacks in units A and B with a high-rate link only from A to B. In this particular example, the return link for link 2 applies both the PHY_1 and MAC_1 layers of link 1. This means that any control information (e.g. acknowledgements of packets) referring to the traffic on link

2 is carried by link 1. This means that the return link is not visible at all on the medium where link 2 is mapped upon. As an example, we take Bluetooth and its high-rate mode. Classic Bluetooth uses a frequency-hopping scheme with a channel bandwidth of 1 MHz. The channel hops over a range of about 80 MHz in the 2.4 GHz ISM band. The proposed high-rate mode (see US patent application 09/385,024 filed August 30, 1999, entitled Resource Management in Uncoordinated FH Systems by J.C. Haartsen) uses a static channel of 4 MHz which is positioned somewhere in the 80 MHz band in the 2.4 GHz ISM band using a Dynamic Channel Selection algorithm. In the embodiment according to Figure 7, the traffic from unit A to unit B is transported over the 4 MHz, wideband channel. However, the corresponding acknowledgement of the retransmission scheme, and the flow control information is carried over the frequency-hopping channel. The access to the 4 MHz channel and the access to the FH channel is completely separated. Therefore, in unit B the MAC_2 mechanism for the wideband reception and the MAC_1 mechanism for the return, narrowband transmission are completely separated. That is, the forward and return streams are split at the DLC' level. Likewise, are the MAC_2 mechanism for the wideband transmission and the MAC_1 mechanism for the return, narrowband reception in unit A completely separated

However, also an alternative embodiment can be envisioned. In that case, the MAC protocol is used for both the high-rate forward transmission and basic rate return transmission. However, the PHY layers are different for the forward and return link, see Figure 8. This would mean that the return link applies the same medium and access technique as the forward link, but the packetizing and RF modulation schemes are corresponding to the PHY layers for the high-rate and basic rate, respectively. For the Bluetooth and its high-rate mode, this means that the return link uses the same static RF frequency as the forward link, but it uses the conventional narrowband modulation and packets. In this second embodiment, the forward and return streams split at the MAC layer.

If a distributed MAC protocol is applied as proposed for the Bluetooth high-rate link, both embodiments pose an extra complication as the high-rate receivers of other units participating on the high-rate channel cannot decode the narrowband transmission in the return link. This can be overcome by informing other users on the high-rate channel of the fact that unit B will respond to high-rate transmission on the low-rate channel. Either the units can switch to this basic mode to listen to the return channel, or they take into account the time duration the return message occupies the medium.

Summarizing, this invention has described asymmetric dual-mode transceivers that can transmit and receive in a basic rate, but can only receive or only transmit in the high rate. The feedback/control information associated with the information sent on high-rate channel is transported by the low-rate channel. The invention allows solutions with reduced cost as complicated transmitters can be omitted in transmit-only applications, while complicated receivers can omitted in receive-only applications.

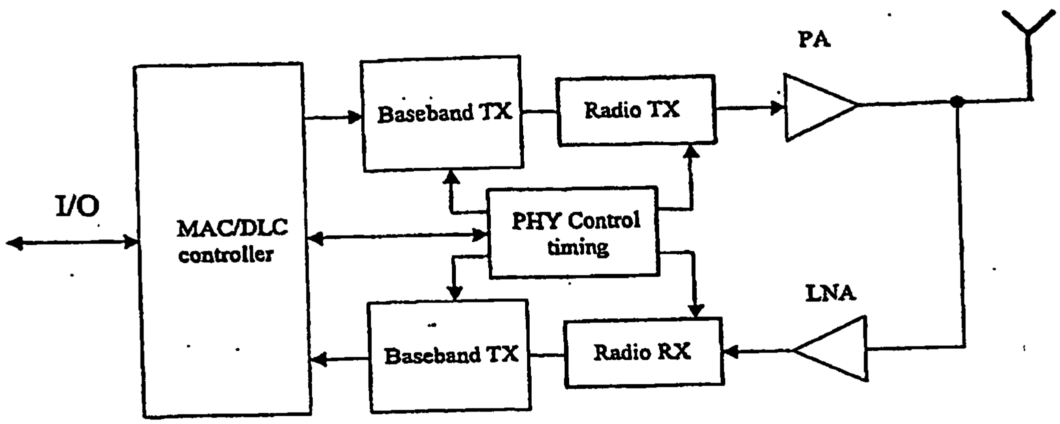


Figure 1

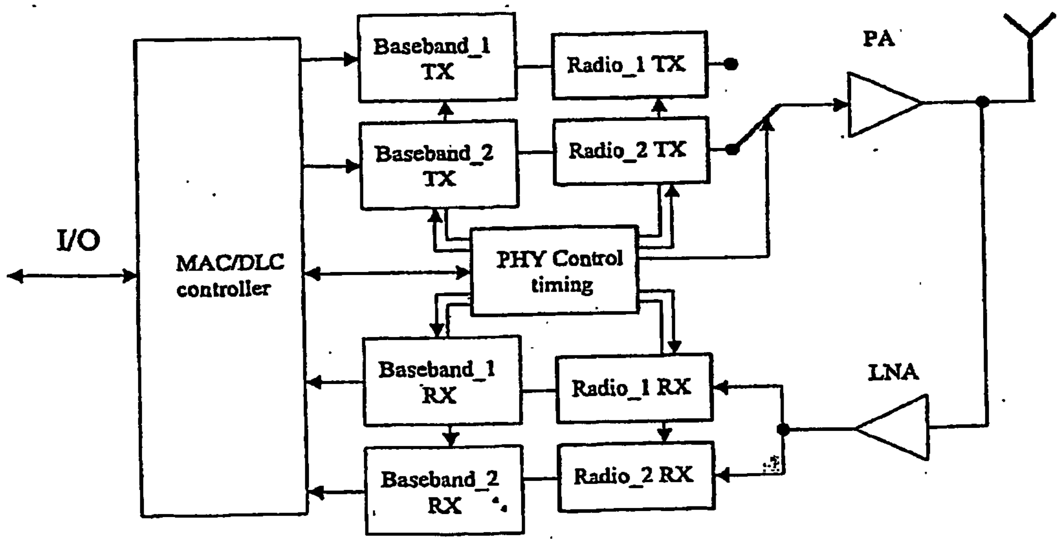
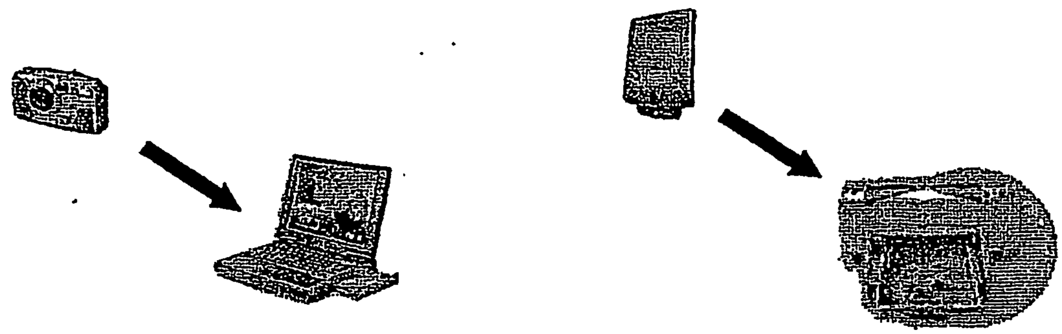


Figure 2



a) b)

Figure 3

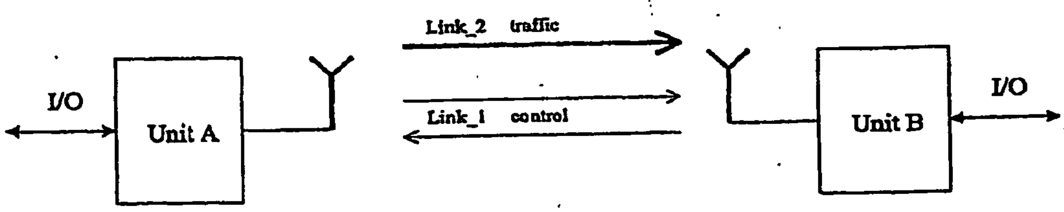


Figure 4

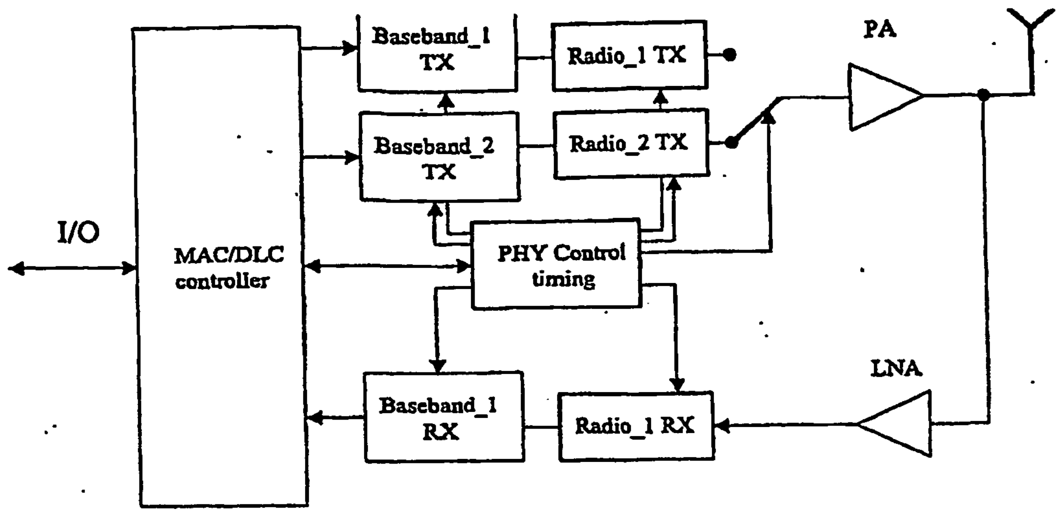


Figure 5a

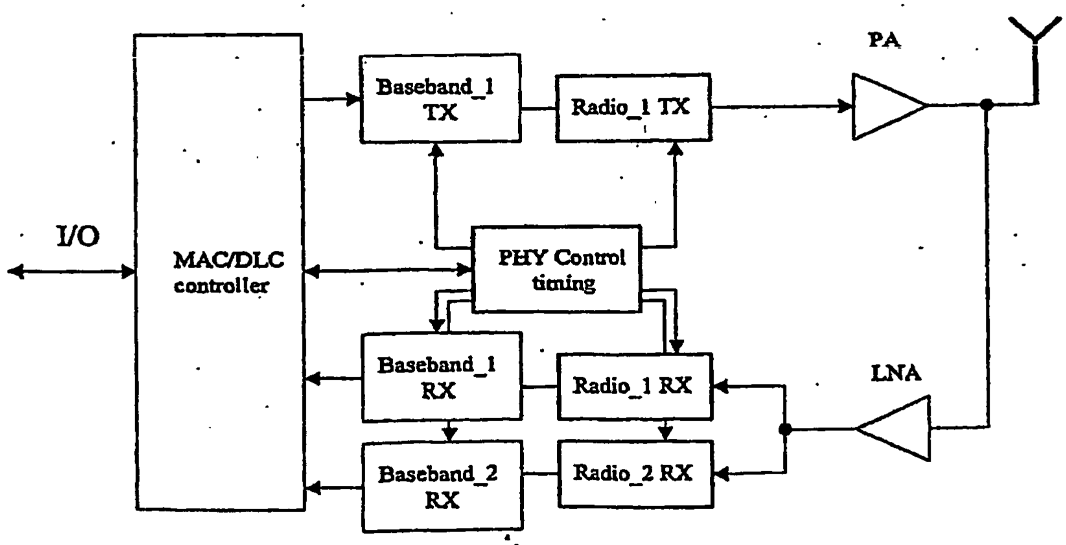


Figure 5b

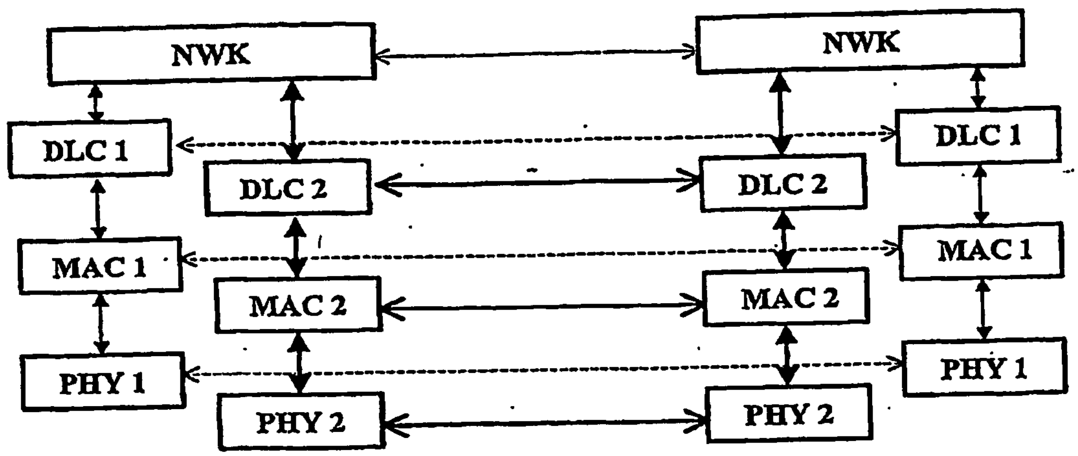


Figure 6

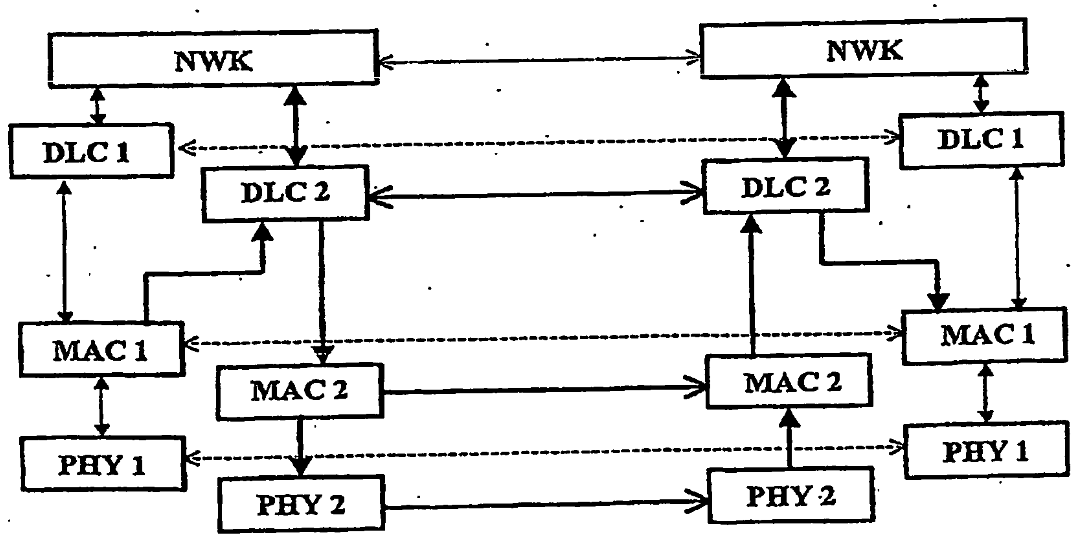


Figure 7

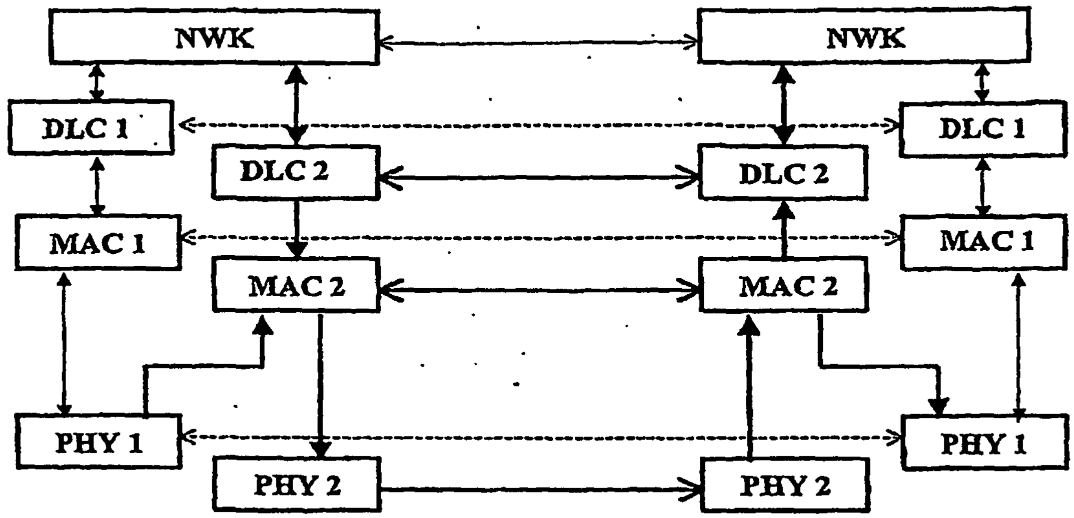

NWK
NWK
DLC 1
DLC 2
DLC 2
DLC 1
MAC 1
MAC 2
MAC 2
MAC 1
PHY 1
PHY 2
PHY 2
PHY 1

Figure 8